Effect of Compost, Nitrogen and Phosphorus Fertilizers on Nutrient Content, Growth and Yield of Tomato and Cucumber under Greenhouse Conditions

By

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Dedication

Grateful to my God who gave me the strength to complete this work, to my mother’s effort and sacrifice to bring my dreams from nothing to reality, my lovely father, my sisters, my teachers, my friends and my colleagues in ARC.

Yasmin…….
ACKNOWLEDGMENTS

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Thanks are also extended to my family my father Yousif Ahmed my mother Awatif and my sisters Eslam, Esraa, THuria. Also Special thanks go to my friend for encouraging me throughout this study.
Effect of Compost, Nitrogen and Phosphorus Fertilizers on Nutrient Content, Growth and Yield of Tomato and Cucumber under Greenhouse Conditions

Yasmin Yousif Ahmed Alfadial

Abstract

Nitrogen and phosphorus are two essential macro nutrients for plant growth. Compost is used as a soil amendment to improve soil biological, chemical and physical properties. This experiment was conducted during the season 2016/17 in a riverine silt loam soil in a cooled plastic house located in the University of Gezira, Wad Medani, Sudan (latitude 14° 24′ N, longitude 31° 33′, altitude 411 masl). The climate is classified as semi arid. The objective of this study was to determine the effect of compost, combined with N and P fertilizers, on nutrient content, growth and yield of tomato, variety Termis and cucumber, variety Leader. Sources of N and P were urea and TSP, respectively. The experiment was carried out in a split-plot design, with three replicates. The main plots were assigned to levels of the chemical fertilizers (0N/0P and 20gN+10gP2O5/m²) applied at sowing. The subplots were assigned to levels of compost (0C and 2.5 kg compost /m²) which was banded in the soil before planting. The results showed that, application of compost alone or combined with the chemical fertilizers significantly (P≤0.05) increased K content of leaves and fruits of tomato. It also significantly (P≤0.05) increased nitrogen content of leaves of cucumber and fruits of tomato and P content of both leaves and fruits of tomato. The results also showed no significant differences at 15, 30 and 55 days after transplanting (DAT) of tomatoes due to application of both mineral and compost fertilizers or their combinations on plant height and number of leaves. However, data obtained at 45 DAT showed that, application of mineral fertilizers alone significantly (P≤0.05) increased growth parameters. Mineral fertilizers alone or combined with compost gave a highly significant increase (P≤0.01) in number of tomato fruits pre plant over that of compost and control treatments. The maximum number of fruits was obtained with the application of mineral fertilizer combined with compost. The application of compost alone significantly increased (P≤0.05) the number of fruits compared to that of the control treatment. A significant increase in yield was obtained due to separate applications of compost (P≤0.01) and chemical fertilizer (P≤0.05) over that of the control. Application of chemical fertilizers combined with compost showed high yield without significant difference over that of the treatment that received both compost alone or chemical fertilizers alone. The results of cucumber showed high significant increases (P≤0.01) in plant height, number of leaves and yield due to application of compost alone or combined with mineral fertilizer over that of the treatment that received the chemical fertilizers and control. It is recommended to apply compost with chemical fertilizers to increase yields of tomato and cucumber under greenhouse conditions.
تأثير السماد العضوي وأسمده النتروجين والفسفور على محتوي المغذيات ونمو وإنتاج الطماطم والخيار تحت ظروف البيوت المحمية

ياسمين يوسف أحمد الفاضل

ملخص الدراسة

النتروجين والفسفور من العناصر الرئيسية الاساسية لنمو النبات، وأما السماد العضوي فيعمل كحسن للترة من خلال تحسين الخواص البيولوجية والكيمائية والفيزيائية. أجريت هذه التجربة خلال موسم 2016-17 في تربة طميية غريبة نهريه ودبل ديمدنى الفاضل على خطى تقاطع 31 ، 033 و دائرة عرض 014 ش وارتفاع 411 متر فوق سطح البحر حيث يوصف مناخ المنطقة بالمناخ شبه الجاف. تهدف الدراسة لتحديد تأثير إضافة الكمبوست والأسمدة المعدنية للنتروجين والفسفور على محتوي العناصر ونمو وإنتاج الطماطم والخيار. صممت التجربة على نظام القطع المنشقة مع ثلاث مكررات. وضعت في القطع الرئيسية الأسمدة الكيميائية وتضمنت مستويين (صفر نتروجين وصفر فسفر) وخلط بين (20 جرام نتروجين و 10 جرام 02P2O5 متر2) و كمبوست 2.5 كجم/متر2 مضارداً داخل نطاق التربة قبل الزراعة. أظهرت النتائج إضافة السماد المعدني أو مع الكمبوست أدى إلى زيادة معنوية في كمية البوتاسيوم في أوراق وثمار الطماطم، وزيادة معنوية (P≤0.05) في كمية النتروجين في أوراق وثمار الطماطم. إضافة السماد المعدني أو الكمبوست أدى إلى زيادة معنوية (P≤0.05) في كمية الفسفر في أوراق وثمار الطماطم، بينما أظهرت النتائج بعد 45 يوماً من الشتل أن إضافة السماد المعدني أدت إلى زيادة معنوية (P≤0.05) في عوامل النمو بالنسبة للطماطم. وأيضاً أظهرت النتائج أن إضافة كل من السماد المعدني و الكمبوست أدت إلى زيادة معنوية عالية (P≤0.01) في عدد ثمار الطماطم، كما أن إضافة السماد المعدني أدت إلى زيادة معنوية (P≤0.05) على التوالي مقارنة بالشاهد. إضافة السماد المعدني أدت إلى زيادة معنوية (P≤0.01) على التوالي مقارنة بالشاهد. وأظهرت النتائج أيضاً بالنسبة للخيار أن إضافته بدون فروقات معنوية مقارنة مع إضافة كل منهما على حدة. وتأتي النتائج أيضاً بالنسبة للخيار أن إضافته الكمبوست لوحده أو مع السماد المعدني قد أدت إلى زيادة معنوية (P≤0.01) في عدد ثمار الطماطم. ونشكر الدراسة بإضافة السماد المعدني لزيادة إنتاجية الطماطم والخيار تحت ظروف البيوت المحمية.

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CHAPTER ONE
INTRODUCTION

Soil fertility can be presumably enhanced by application of organic and inorganic fertilizers. However, the use of any type of fertilizer depends on several factors such as soil type, nature of crop and socio-economic condition of the area. The trend towards organic agriculture is evolving strongly, organic fertilizers are considered as one of the important items of organic agriculture. Use of organic fertilizers is highly encouraged due to the presence of high livestock population, while inorganic fertilizer are costly, and cannot be afforded by the small holder and traditional vegetable producers (Babiker and Mustafa, 2005). The application of organic fertilizer combined with or without mineral fertilizer to soil is considered as a good management practice in any agricultural production system, it improves plant quality and soil fertility. Daily production of large quantities of solid organic wastes causes serious disposal problems, environmental pollution and possible health risks. Using a good strategy such as composting process, solid wastes can be converted into useful products for improvement of soil properties (Hashemimajd et al., 2004; Yourtchi et al., 2013).

Organic fertilizers comprise a variety of plants- that range from fresh or dried derived material and animal manures (Wohlfarth and Schroeder, 1979; Das and Jana, 2003). Organic fertilizers include compost, farmyard manure (FYM), green manure, chicken manure, and others. Composting is a biological process by which microorganisms convert organic materials into dark humus; rich soil - like material called compost. It is intentional creation of conditions that result in more rapid decomposition of organic material than what would normally occur in nature. Composting is a simple rewarding way to recycle organic wastes, and the compost, is a valuable soil amendment for gardens and lawns (Park et al., 2002).

The greenhouse technology was considered as an effective technology which can improve continuously the productivity, profitability, sustainability of farming systems by providing favorable environmental conditions to the plants. It is rather used to protect the plants from the adverse climatic conditions such as wind, cold, precipitation
and excessive radiation, extreme temperature, insects and diseases. It is also of vital importance to create an ideal micro climate around the plants (Shakuntala and Anil, 2015). Greenhouses are suitable for growing vegetables in a number of ways such as starting off hardy vegetable plants earlier than outdoors and growing tender crops such as, cucumbers, peppers and tomatoes through the summer season (Coleman, 2009). Besides supplying the local markets, the production of greenhouse vegetables is greatly valued for its export potential and plays an important role in the foreign trade balance of several national economies (Kittas et al., 2013).

Tomato (*Solanum lycopersicum* (L) Mill.) and Cucumber (*Cucumis sativus* L.) are important vegetables worldwide, which are mostly grown vegetables in greenhouses (Lower and Edwards, 1986; Thoa, 1998). High temperature is considered as a major environmental stress that limits tomato production during summer under arid conditions (Portnee, 1996). Tomatoes are grown under irrigation in the arid tropics where, commercial production is limited to relatively short periods of favorable climate during the winter months of November to March. The productivity of tomato is markedly decreased in Sudan and consequently there is a drastic shortage in the availability of tomato to consumers in summer (April to September). Protected vegetable production under cooled plastic house is a newly introduced technology in the Sudan. It was introduced rather late in the early nineties of last century and was successfully used to produce tomatoes and cucumbers at El Hasaheesa, Gezira State (Elamin, 2007).

In general, chemical fertilizer application rates in intensive agricultural systems have increased dramatically during recent years, especially in greenhouse vegetable production systems, because of higher yields and income. In agricultural systems more than 70% of applied N fertilizer is lost to the environment, which has very costly and destructive consequences (Basel and Sami, 2014). However, the use of inorganic fertilizers alone may cause problems for human health and the environment that means the excess use of chemical fertilizers in agriculture can lead to nitrate accumulation into plant parts especially on edible parts (Abd El-Hamied, 2001). Nutrient uptake concentration is a parameter used by some authors (Sonneveld, 2000; Savvas, 2002; Carmassi et al., 2007; Sonneveld and Voogt, 2009; Massa et al., 2011) to model the crop uptake of both nutritive and non-essential ions.
The complementary use of organic and inorganic fertilizers has been recommended for sustaining long term cropping in the tropics (Abdelmageed et al., 2004). Another added value is the use of agricultural by-products thus lowering the cost of production that relies on chemical fertilizer. The effects of organic fertilization and the combined use of chemical and organic fertilizer on crop growth and soil fertility depends on the application rates and the nature of fertilizers used (Tzen and Chen, 2004). In many parts of the world, many greenhouse growers still determine fertilizer application rates by a “rule of thumb”. In most cases, this practice results in excessive application rates for nitrogen, phosphorus and potassium.

1.1 Problem identification and justification

It becomes apparent from the above statements that, there is lack of information about fertilization packages in green house conditions in Sudan, so this experiment was carried out to come up with conclusions and recommendations leading to adoption of the fertilization methodologies under protected greenhouse condition aiming at production of tomato and cucumber for local consumption and export, in particular the application rates of chemical and compost fertilizers and their combinations.

1.2 Objectives of the study

This research was carried to study the effect of added locally made compost and Nitrogen and Phosphorus fertilizers and their combinations on nutrient uptake, growth and yield of Tomato (*Solanum lycopersicum* (L) Mill.) and Cucumber (*Cucumis sativus* L.) under greenhouse conditions.
CHAPTER TWO
REVIEW OF LITERATURE

2.1 Greenhouses for Vegetable Production

Greenhouse (also called a glasshouse) is a structure like dome or square shape that allows a farmer to grow crops, especially vegetables - tomato, sweet pepper, cucumber, green beans, in a controlled environment, it is a covered structure that protects the plants from extensive external climate conditions and diseases, creates optimal growth microenvironment, and offers a flexible solution for sustainable and efficient year-round cultivation (Shamshiri et al., 2018). Depending upon the technical specification of a greenhouse, key factors which may be controlled include temperature, levels of light and shade, irrigation, fertilizer application, and atmospheric humidity. Greenhouse systems are mainly used for production of vegetables during an extended summer season, both early and late, and sometimes for the production of winter leafy vegetables. The cropping systems and degree of intensification differ widely between countries, regions and growers, due to the more extreme climatic conditions and sometimes also for historical reasons, and economic conditions. Intensive systems are found only on specialized farms, with greenhouse production as the unique activity. Generally speaking, greenhouse structures in use for organic production are mainly glass-houses including plexi-glasses. They were initially meant to protect the crops from the harsh climate and competition. Greenhouses are equipped with a lot of technology to increase yield and enable long season and even year-round cultivation (Tittatelli et al., 2016).

The advantages of greenhouses according to Shakuntala and Anil, (2015) are:

- The yield may be 10-12 times higher than that of outdoor cultivation depending upon the type of greenhouse, type of crop, environmental control facilities.
- Reliability of crop increases under greenhouse cultivation.
- Ideally suited for vegetables and flower crops.
- Year round production of floricultural crops.
- Off-season production of vegetable and fruit crops.
- Disease-free and genetically superior transplants can be produced continuously.
• Efficient utilization of chemicals, pesticides to control pest and diseases.
• Water requirement of crops very limited and easy to control.
• Maintenance of stock plants, cultivating grafted plant-lets and micro propagated plant-lets.
• Hardening of tissue cultured plants.
• Production of quality produce free of blemishes.
• Most useful in monitoring and controlling the instability of various ecological System
• Modern techniques of hydroponic (Soil less culture); Aeroponics and Nutrient film techniques are possible only under greenhouse cultivation.

In recent decades, greenhouse area has raised worldwide, due mainly to the increased use of greenhouses for growing vegetable crops. Site selection is a key factor for profitable and sustainable greenhouse production. The main factors determining location and site selection of a greenhouse production are: cost of production, quality of produced yield, and transportation cost to markets (Nelson, 1985; Castilla and Hernandez, 2007).

Sudan weather conditions are characterized by having predominantly long and hot summers, and short and mild winters, such climatic conditions put a great strain on the type of crops that could be successfully grown. This is very much true with most horticultural vegetables with medium thermal requirements i.e. tomato, pepper, cucumber, melon, water melon, marrow, green bean and eggplant. (Salah and Azmi, 2015). The number of greenhouses during the last few years (2009-2011) in Sudan reached 764 G/house (Khartoum State Ministry of Agriculture, 2011). Cucumbers and tomatoes are two most popular crops grown in greenhouse by vegetable growers(Salah and Azmi, 2015).

2.2 Fertilization in greenhouses

Maintaining adequate nutrition is among the most critical aspects of producing greenhouse crops. The balance of plant nutrients is important in producing vigorous and efficient plants. In some cases when nutrients are out of balance, severe deficiencies or toxicities may occur. Therefore, it is important to consider both the source and amount of fertilizer used, for vegetable crops (Fageria, 2002). In many parts of the world, many
greenhouse growers still determine fertilizer application rates by a “rule of thumb”. In most cases, this practice results in excessive application rates for nitrogen, phosphorus and potassium which are a cause of concern regarding agricultural resources and food quality (Gianquinto et al. 2013). In some cases, excessive application of one or more nutrients is accompanied by inadequate supply of other nutrients, thereby exacerbating the incidence of single-nutrient toxicities or deficiencies, or even resulting in multinutritional disorders. Kläring (2001) reported that, traditional management of nutrients in greenhouse production is based on the assumption that plant growth is not limited by water and nutrient uptake. Other growers utilize a liquid feed program as their primary means of supplying plant nutrients. This program may also be supplemented with granular or slow release fertilizers added to the growing medium. Liquid fertilizer applied through irrigation lines is a technique known as fertigation which is a common practice in greenhouse production. Nitrogen and phosphorus are the two primary nutrients injected through fertigation systems. The injection of organic fertilizers into low-volume irrigation systems like drip emitter and micro sprinkler is unconventional, because the standard method relies on commercial synthetic fertilizers that are highly soluble in water (Schwanki and Glen, 1992).

In Greenhouses, if fertilization is not well managed in soil-grown crops e.g. excessive amounts of fertilizer, fertilizers distributed only at planting without splitting nitrogen rate throughout the growing season, a water surplus is often necessary to avoid soil salinization and to keep soil moisture high. Additional fertilization is then necessary to compensate for nutrient losses caused by leaching (Kläring, 2001).

**2.3 Chemical fertilizers**

Mineral fertilizers are used to supplement the natural soil nutrient supply in order to satisfy the demand of crops with a high yield potential and produce economically viable yields; compensate for the nutrient lost by the removal of plant products or by leaching or gaseous loss (IFIA, 2000).

Conventional production uses chemical fertilizers mainly urea, superphosphate and potash. Although chemical fertilizers have been claimed as the most important
contributors to the increase in world agricultural productivity over the past decades (Smil, 2001). Peyvast et al. (2008) showed that, the negative effects of chemical fertilizer on soil and environment limit its usage in sustainable agricultural systems. The continuous use of chemical fertilization leads to deterioration of soil characteristics and fertility, and may lead to the accumulation of heavy metals in plant tissues which compromises fruit nutrition value and edible quality (Shimbo et al., 2001). Marzouk and Kassem, (2011) reported that, chemical fertilizer also reduces the protein content of crops, and the carbohydrate quality of such crops also gets degraded. Boller and Hani, 2004, indicated that urea as a good source of nitrogen must be used carefully as it will promote an excess of green growth and make plant weak, spindly and susceptible to disease. Ouyang et al. (2014); Eriksen et al. (2015), stated that, unreasonable fertilization can lead to agricultural non-point source pollution, and improvements are necessary to avoid adverse environmental impacts of nitrate leaching. Excess potassium content on chemical over fertilized soil decreases vitamin C, carotene content and antioxidant compounds in vegetables (Tooreal.,2006).Vegetables and fruits grown on chemically fertilized soils are also more prone to attacks by insects and diseases (Karungi et al., 2006).

According to Chen (2006) the advantages of chemical fertilizers are as follow:

- Nutrients are soluble and immediately available to the plants.
- The price is lower and more competitive than organic fertilizer.
- They are quite high in nutrient content and therefore relatively small amounts are required for crop growth.

Disadvantages of chemical fertilizers are as follow:

- Over-application can result in negative effects such as leaching, pollution of water resources, destruction of microorganisms and friendly insects, crop susceptibility to disease attack, acidification or alkalization of the soil or reduction in soil fertility — thus causing irreparable damage to the overall system.
- Oversupply of N leads to softening of plant tissue resulting in plants that are more sensitive to diseases and pests.
- They reduce the colonization of plant roots with mycorrhizae and inhibit symbiotic N fixation by rhizobia due to high N fertilization.
• They enhance the decomposition of soil OM, which leads to degradation of soil structure.
• Nutrients are easily lost from soils through fixation, leaching or gas emission and can lead to reduced fertilizer.

2.4 Organic farming

Organic farming is a production system which avoids or largely excludes the use of synthetic compound fertilizers, pesticides, growth regulators and livestock feed additives. The organic system relies on crop rotations, crop residues, animal manures, green manures, legumes, to supply plant nutrients and to control insects, weeds and other pests (Panda, 2012).

The aims of organic production system is supporting and sustaining healthy ecosystems, soil farmers, food production for the community, and the economy. The organic farming aims at reduction and elimination of the adverse effects of synthetic fertilizers and pesticides on human health and the environment (Aksoy, 2001; Chowdhury, 2004). It also caters for producing high quality food in sufficient quantities, to maintain and improve soil fertility in the long term (sustainability), to foster the use of renewable resources if possible from local origin of agricultural practices (Stockdale et al., 2001).

Scientific and agricultural symposia discussed the increased use of mineral fertilizers and the corresponding neglect of organic manures as a major cause of several problems for example soil compaction caused by the use of machinery and reduced organic manuring lowered the soil’s water-retaining capacity, causing drought problems. In appropriate use of mineral fertilizers was disturbing plant metabolism, especially because cultivars, at that time, were not yet adapted to higher nitrogen levels in soil. Weakened plants could be attacked more easily by pathogens and insect (Summarized in Vogt, 2000a).

2.5 Organic fertilizers

Organic fertilizers contain macronutrients, essential micronutrients, vitamins, growth promoting indole acetic acid (IAA), gibberellic acid (GA) and beneficial microorganisms (Sreenivasa et al., 2010). Organic fertilizers are environmentally friendly, since they are
from organic sources (Oyewole et al., 2012). Lin et al. (2010) reported that, application of organic fertilizers is one of important practical measures to improve soil fertility. In addition to providing necessary nutrients for crops and improving soil physico-chemical properties, organic fertilizer is able to enhance soil microbial activity of soil, such as improving activity of soil enzymes and increasing soil microbial biomass. Organic fertilizers, which mainly come from agricultural waste such as cow manure and compost or municipal solid waste compost, are often identified as suitable local organic fertilizers. These contain high levels of nutrients, e.g. N and P and high amounts of organic matter (Peyvast et al., 2007; Peyvast et al., 2008; Olfati et al., 2009 Shabani et al., 2011), and according to their studies, the usage of organic fertilizers can be an effective alternative to chemical fertilizers. However, the apparent deficiency of an adequate supply of plant – available N from organic fertilizer, resulting from a slow rate of mineralization, makes crop yields in fields treated with organic fertilizer lower than that of fields treated with chemical fertilizer (Blatt, 1991; Lee, 2010). Organic fertilizers should be used in appropriate amounts to achieve suitable yield and quality. High C relative to N will lead to a tie-up of N, potentially causing N deficiency in the crop. A C/N ratio of 25/1 or greater will lead to N tie-up in the soil. A C/N ratio of less than 25/1 will release N to the crop. The C/N ratio is also an important consideration in the use of various composts, as well as a controlling factor in the composting process itself and the availability of N in manure or compost will not all be available to the crop the first year (Carl and Peter, 2005). In non-composted manure, some of the N will be lost to the atmosphere during application in the form of ammonia gas. Manure applied to land should be incorporated as soon as possible after application to avoid ammonia losses. Because the N is stabilized in organic compounds, atmospheric losses of ammonia are not as critical in compost applications, although incorporation is highly recommended. N in the organic form will need to be broken down by microorganisms before plants can use it. The release of N from manure or compost will depend on the type and age of the manure. Anywhere from 5 to 90 percent of the organic N can be released to useable forms the first year. For dairy manure, 40 to 60 percent of the N is generally considered to be available the first year, and 30 to 40 percent of the N is available the second and third years. Evelyn et al. (2009) discussed the soil organic carbon (SOC) of a sandy soil could be increased from 0.7 to
0.9% over 6 years by return of crop residues, which was associated with a consistent increase in arable crop and yields. Subsequent annual applications of farmyard manure (FYM) increased SOC from 1% to 3.4% whereas long-term application of fertilizer N had no measurable effect on SOC levels.

According to Chen (2006) the advantages of organic fertilizers are as follow:

- The nutrient supply is more balanced, which helps to keep plants healthy.
- They enhance soil biological activity, which improves nutrient mobilization from organic and chemical sources and decomposition of toxic substances.
- They enhance the colonization of mycorrhizae, which improves P availability.
- They enhance root growth due to better soil structure.
- They increase the organic matter content of the soil, therefore improving the exchange capacity of nutrients, increasing soil water retention, promoting soil aggregates and buffering the soil against acidity, alkalinity, salinity, pesticides and toxic heavy metals.
- They release nutrients slowly and contribute to the residual pool of organic N and P in the soil, reducing N leaching loss and P fixation; they can also supply micronutrients.
- They supply food and encourage the growth of beneficial microorganisms and earthworms.
- They help to suppress certain plant diseases, soil borne diseases and parasites.

Disadvantages of organic fertilizers are as fellow:

- They are comparatively low in nutrient content, so larger volume is needed to provide enough nutrients for crop growth.
- The nutrient release rate is too slow to meet crop requirements in a short time; hence some temporary nutrient deficiency may occur.
- The major plant nutrients may not exist in organic fertilizer in sufficient quantity to sustain maximum crop growth.
- The nutrient composition of compost is highly variable; the cost is high compared to chemical fertilizers.
Long-term or heavy application to agricultural soils may result in salt, nutrient or heavy metal accumulation and may adversely affect plant growth, soil organisms, water quality and animal and human health.

2.5.1 Compost

Compost is organic matter (plant and animal residues which have been rotted down by the action of bacteria and other organisms, over a period of time. Its definition is to transform raw organic residues into humus-like material through the activity of soil microorganisms. Mature compost stores well and is biologically stable, free of unpleasant odors, easier to handle and less bulky than raw materials. Compost can be used as a soil amendment, seed starter, mulch, or natural fertilizer, depending on its characteristics of the raw materials.

Ibrahim and Fadni (2013) reported that, addition of organic fertilizers on growth of tomato in sandy soil that found change in the soil physical chemical properties and increase organic matter especially the indicator increase significantly growth of tomato. Manal et al. (2017) studied the effect of compost, green manure and nitrogen fertilizer on performance of sweet pepper and soil properties of the Gezira. She found that application of compost and green manure alone or in combination with mineral nitrogen improved soil properties and hence growth and yield of sweet pepper. Fatimah et al. (2016) studied the effect of some organic fertilizers on growth and yield of tomato she found that chicken manure has the significant effect than compost at least influential in growth stage.

2.5.2 Uses and Benefits of Compost

Compost organics can be used as a soil amendment along roadways in order to reduce erosion, facilitate revegetation and promote soil regeneration. Numerous studies have shown that compost and mulches applied as soil surface blankets can reduce runoff and sediment loss form slopes as compared to bare slopes or treated slopes without mulch cover (Demars et al., 2000; Glanville et al., 2004; Faucette et al., 2004; Grismer and Hogan, 2005). Compost has two main effects on soil properties, particularly in poor fertile soil. First, it improves organic matter content and then provides essential macro
and micro nutrients for plant growth (Sanchez-Moneru et al., 2004; Tejada et al., 2009b). Moreover, favorable special effects of compost is to increase water holding capacity and available plant water (CIWMB, 2004; Curtis and Classen, 2005; Farrell and Jones, 2009). Beneficial effects of composts include enhanced seed germination, plant yield, root growth, tolerance to different plant stresses and increase in plant resistance to infections or insect attack. Nevertheless, researchers have reported mixed results on the effectiveness of these products (Tourte et al., 2000).

Compost is mainly applied to the soil as an amendment, even if its mineral composition suggests it as a potential mineral fertilizer. In fact, compost application improves plant growth by supplying sufficient nutrients to plant (Togun and Akanbi, 2003) and affecting the levels of nutritional elements in soil (Giusquiani et al., 1988). Furthermore, addition of compost to the soil could influence positively plant yield and that the yield increase is always directly related to the nutrients in compost but could depend on the general improvement of the soil physical properties. Generally, the benefits of compost amendments are soil borne-disease reduction, soil moisture conservation and weed control as well as reduction of the need for water soluble fertilizer (Stoffila and Kahn, 2001).

2.6 Tomato (*Solanum lycopersicum* (L) Mill.)

Tomato (*Solanum lycopersicum* (L) Mill.) is a member of the family Solanaceae and is native to Central, South and Southern North America from Mexico to Peru (Saifeldin and Ali 2012). Greenhouse tomato and cucumber are very popular in many areas of the world (ALMoshileh et al., 2017). In Sudan, tomatoes and cucumbers are considered the most important vegetable crops grown under greenhouse conditions. Tomato is a popular grown vegetable and rank third of worldwide vegetable production (Sadaf et al., 2012). Tomato occupies the second order in Sudan vegetable production after onion. Abu-sarra (2007) stated that world tomato production in 2001 was about 105 million tons of fresh fruit from an estimated 3.9 million ha. In the Sudan Tomato product is considered as most important vegetable crop due to its economics and nutritional value. It occupies about 28% of the total area under vegetables production in Sudan (Ahmed, 2009).
Tomatoes contribute to healthy, well balanced diet because they are rich in minerals, Vitamins B and C, Iron and phosphorus. Tomato fruits are consumed fresh in salads or cooked in sauces, soup and meat or fish dishes. They can be processed into puree Juices and ketchup. Canned and dried tomatoes are economically important processed products (Fatimah et al., 2016).

As it is a relatively short duration crop and gives a high yield, tomato is economically attractive to farmers and the area under cultivation is increasing consistently (Naika et al., 2005). Greenhouse cultivation increases the production period. Use of fertilizers is one of most important factors facing vegetable production in green houses due to the high plants density, and the increased needs for plant nourishment. The tomato crop is considered a crop with major fertilization requirements (Badr et al., 2010). Abu-sarra et al. (2005) stated that, addition of fertilizers is important for getting higher tomato yield and adding high level of nitrogen (86 k N/ha) produced tomato yield similar to that of soil dressed with moderate nitrogen level (43 kg N/ha).

2.7 Cucumber (Cucumis sativus L.)

Cucumber is a member of the cucurbitaceae family. Members of this family spread mainly in tropical and subtropical regions of the world (Wang et al., 2007). Cucumber originated in India and becomes popular throughout the Egyptian and Greek – Roman Empire (Renner et al., 2007). Cucumber ranks four after tomatoes, cabbage and onion in Asia (Tatlioglu, 1997; Eifediyi and Remison, 2010). The cucumber is a very popular crop for greenhouses production (Hochmuth, 2005).

The soils where cucumber is cultivated require moderate to high nutrient levels so as to achieve high yields. Infertile soils result in bitter and misshapen fruits which are often rejected by consumers; thereby reducing farmer's income (Eifediyi and Remison, 2010). Cucumber is a rich source of vitamin B, vitamin C and minerals such as phosphorus, potassium, calcium and iron (Karnataka, 2012). The cucumber fruits are eaten fresh in salads in accompaniment with other vegetables (AbdElHafeez and Ali, 2013).

Application of organic fertilizer increases cucumber production, vitamin C, protein, sugar and decrease nitrate accumulation in cucumber fruit (Hong et al., 2014). The nutrient uptake rate by greenhouse cucumbers is very high (Dickerson, 1996).
2.8 Effect of Nitrogen on plant growth and yield of tomato and cucumber

Eckert (2005) stated that the earth atmosphere contains 78 percent N\textsubscript{2} by volume, which is the sole source of soil nitrogen. It enters the soil through rainfall, after oxidation by lightning, plant and animal residues, biological and chemical fixation. Nitrogen into plant available forms of nitrogen. Three fixations of nitrogen involve ammonia fertilizers (production in industry), lightning (through thunderstorm activity) and biological fixation.

Nitrogen is an essential element required for successful plant growth. Inorganic nitrogen compounds (i.e., NH\textsubscript{4}\textsuperscript{+}, NO\textsubscript{2}\textsuperscript{−}, and NO\textsubscript{3}\textsuperscript{−}) account for less than 5% of the total nitrogen in soil. The plant available forms of nitrogen (NO\textsubscript{3}\textsuperscript{−} and NH\textsubscript{4}\textsuperscript{+}) are taken by plant roots and also plant can absorb NH\textsubscript{3} directly through the leaves dependent on the amount of the air NH\textsubscript{3} concentration (Biernman, 2001). Nitrogen is a component of chlorophyll, amino acids, enzymes, ATP, DNA and RNA (Eckert, 2005). N fertilizers with acidifying potentiality have the capacity to decrease soil pH and increase the trace elements uptake by plants. Decrease in soil pH by some N fertilizers during the plant cultivation is mainly due to ammoniacal compounds and therefore, fertilizers containing NH\textsubscript{4}salts are potentially acidifying and can affect the trace elements uptake by plants (Ohtani et al., 2007; Parvizi et al., 2004). Nitrogen is an important nutrient for plant growth and yield but is difficult to optimize because it is susceptible to leaching, immobilization, denitrification and volatilization (Andersen et al., 1999a; Tremblay et al., 2001). Tomato yields are highly responsive to the application of N (Locascio et al., 1997; Andersen et al., 1999a, b; Tei et al., 2002) and growers have a tendency to apply excess N fertilizer rather than risk under-fertilization and reduced yields (Andersen et al., 1999b; Tremblay et al., 2001). High fertilizer N rates may increase plant growth (Andersen et al., 1999b;Tei et al., 2002), decrease tomato fruit color (Seliga and Shattuck, 1995), increase the amount of green fruit atheraves t(May and Gonzales 1994; Herrero et al., 2001).Ali et al. (2011) reported that, maximum yield of dry matter of cucumber and N, P and K content were obtained by application of the highest doses of N and P as aqua ammonia and phosphoric acid.
2.9 Effect of phosphorus on plant growth and yield of tomato and cucumber

Phosphorus is an essential component of nucleic acids, phospholipids, and energy-rich phosphate compounds, (ATP) thus; it plays a crucial role in root growth, fruit and seed development, and disease resistance. Phosphorus deficiency can stunt plant growth and reduce yield and quality. Over application of P fertilizers, at rates that exceed crop demand, will increase the risk of P losses from soil to water resources and impair water quality through eutrophication (von Wandruszka, 2006).

The main supply of phosphorus to the soil is through the incorporation of plants or animals residues and wastes, and through the application of chemical fertilizers. Any organic matter technology may be thought of as a phosphorus technology, although in general, the emphasis has been to use organic matter technologies to supply nitrogen or soil organic matter rather than to use them for specific objective of increasing soil phosphorus. Most of the total soil phosphorus is tied up chemically in compounds of limited solubility, in neutral to alkaline soils, calcium phosphates are formed, while in acid soils, iron and aluminum phosphates are produced and the available soil phosphorus may be 1% or less of the total amount present (Soil Improvement Committee, 1985; Carrow et al., 2001). Solubility of phosphate in soils is controlled by several factors: the greater the total amount of solid phosphate-phase in the soil, the better chance of having more phosphorus in solution; also the greater exposure of phosphates to soil solution and to the plant roots increases the ability to maintain replacement supplies. The soil pH also affects the solubility of phosphates; maximum availability of soil phosphorus occurs at pH ranging from 6.0 to 7.5 (Beard, 1973; Soil Improvement Committee, 1985; Bockman et al., 1990; Schneider and Morel, 2000). Al-Shammary and Saud (2013); Waleed and Mohammed (2017) reported that, organic fertilizer significantly improved the available phosphorus due to mineralization of organic phosphorus in the organic fertilizer to mineral form.

Hochmuth et al. (2009) reported that, phosphorus is an important nutrient for tomato plant growth and development and that a deficiency of P leads to reduced growth and reduced yields. Tomatoes have the greatest demand for phosphorus at the early stages of
development (Csizinszky, 2005). Abd El-Hafeez and Ali (2013) reported that, growth and yield of cucumber plants significantly responded to phosphorus fertilization.

2.10 Effect of Combination of organic and inorganic fertilizers on plant growth and yield of tomato and cucumber

Based on their chemical composition the use of organic and mineral fertilizers can lead to the improvement of plant yield and the fertility of soil. Most existing studies show positive effects of the combined application of organic amendments and mineral fertilizers on soil fertility by improvement of nutrient and water-holding capacity of the soil, minimizing the leaching losses and maximizing the efficiency of applied nutrient (Amusan et al., 2011; Chivenge et al., 2011).

The complementary use of organic and inorganic fertilizers has been recommended for maintenance of long term cropping in the tropics (Ipimoroti et al., 2002). Islam and Munda (2012), Manoj et al. (2012) reported that, the highest uptake of N, P and K with the application of N, P and K through inorganic fertilizers and organic fertilizer. The combined application of organic and inorganic fertilizer significantly increased cucumber yields compared to the application of each one of them separately particularly at higher rates of application. The increase in yield of cucumber could be attributed to the fact that nutrients were more readily available when organic and inorganic fertilizers were combined (Eifediyi and Remison, 2010). The better performance of tomatoes in terms of growth and yield was observed when organic manure was combined with NPK fertilizer (Ogundare, 2011 and Asadu and Unagwu, 2012).
CHAPTER THREE
MATERIALS AND METHODS

3.1 Location of the Experiment

The experiment was conducted during the period February - May 2017 at the central university laboratory greenhouse, University of Gezira, Wad Medani, Sudan, latitude 14° 24’N, longitude 33° 31’E, and altitude 411 m. asl. The greenhouse is designed to improve the microclimate for horticultural crop production in central Sudan conditions. The greenhouse was established according to its necessary specifications such as; directions (North-South), dimensions (34*9*4 m) and double door position (side position).

3.2 The soil

The soil of the experimental site is riverine silt loam soil and classified as "Typicustifluvents, (Soil Survey Staff, 2014). Composite surface soil samples at depths (0-30) were collected from the experimental area before application of fertilizers for routine physical and chemical analyses. The methods of soil analyses were essentially those of Richards (1954) and Adam (2012).

3.2.1 Particle Size Distribution

Sand fractions were separated by sieves (coarse sand and fine sand), clay fraction was determined by pipette methods (Day, 1965) and silt was determined by the difference between clay and sand fractions.

3.2.2 Soil pH

Soil pH was determined by pH meter portable model, from a saturated soil paste (Ryan et al., 2001).
3.2.3 Electrical Conductivity

Electrical conductivity was determined by an EC meter portable model from an extract of a saturated soil extract (Ryan et al., 2001).

3.2.4 Soluble Cations

Soluble cations were determined in the extract of a saturated soil past and expressed in me/l. Soluble calcium and magnesium were determined by titration with ethylene diamine tetra acetic acid (EDTA) and soluble sodium was determined by digital flame photometer (Richards, 1954), whereas soluble potassium was undetectable.

3.2.5 Soluble Anions

Carbonate and bicarbonate were determined in the extract of the saturated soil paste by titration with hydrochloric acid and soluble chloride was determined by titration of the extract with silver nitrate (AgNO3). (Ryan et al., 2001).

3.2.6 Calcium Carbonates

Calcium carbonate was determined by using titration methods.

3.2.7 Organic Carbon

The organic carbon was oxidized by potassium dichromate in presence of conc. H₂SO₄ Se as catalyst and then determined by titration with ferrous ammonium sulphates solution (Walkley and Black, 1934).

3.2.8 Cation Exchange Capacity (CEC)

Cations exchange capacity was reported as (cmol (+) kg⁻¹ soil). CEC was determined by a centrifuge. Five grammes (5g) of the soil were indexed by 1N sodium acetate trihydrate solution three times, and washed by 95% ethanol three times. The adsorbed (Na⁺) was replaced by (NH₄⁺) acetate solution at pH 7 and the final extract analyzed by using flame photometer at 767nm wavelength (Ryan et al., 2001).
3.2.9 Total Nitrogen

Total soil N (mainly organic) was measured after wet digestion in concentrated H₂SO₄ using Kjeldahl procedure. The inorganic N of the produced (NH₄)₂SO₄ was then obtained by distillation using excess conc. NaOH. The distillate was collected in a mixed boric acid indicator which was then titrated with a standard dilute H₂SO₄ (Ryan et al., 2001).

3.2.10 Available Phosphorus

Available P was extracted from a 5 g of soil shaken with 50 ml NaHCO₃ for half an hour, and then filtered. 10 drops of conc. H₂SO₄ were added. Ascorbic acid 1.5 ml was added and 5ml of the solution was taken and completed to 50 ml with deionized water. The soluble P was measured using spectrophotometer model 6305 according to (Olsen et al., 1954).

3.2.11 Sodium Adsorption Ratio (SAR)

The Sodium Adsorption Ratio (SAR) is determined from analyses of the extract of the saturated soil paste for Na⁺, Ca²⁺, and Mg²⁺ using the following equation:

\[ \text{S.A.R.} = \frac{Na^+}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}} \]

3.2.12 Exchangeable Cations (Na⁺ and K⁺)

Extracted with ammonium acetate and corrected for soluble fractions as measured in saturation extract, then Na and K were determined (Power, 1952).

3.2.13 Exchangeable Sodium Percentage (ESP)

Was calculated according to the following formula:

\[ \text{ESP} = (\text{Exchangeable Na ÷ CEC}) \times 100 \]
3.3 Compost analysis
The primary analyses of raw material form of straw wheat and cattle manure for Compost samples were taken in accordance with the procedure of Drawl (FCO, 1985).

<table>
<thead>
<tr>
<th>pH</th>
<th>EC (dSm⁻¹)</th>
<th>N%</th>
<th>OC%</th>
<th>O.M%</th>
<th>C/N</th>
<th>P %</th>
<th>K%</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.0</td>
<td>3.4</td>
<td>1.2</td>
<td>15</td>
<td>26</td>
<td>13</td>
<td>0.23</td>
<td>2</td>
</tr>
</tbody>
</table>

3.4 Cultural Practices
The greenhouse was divided into two equal parts; each one was allotted to study the treatments effects on Tomato and Cucumber as test crops. The land was prepared manually bringing the soil in leveled beds known as (Mustaba) and plots were constructed with dimensions 2.4 x 0.5m with 50 cm inter plot spacing.

3.5 Sowing date
Cucumber seeds of cultivar leader and tomato seedlings of cultivar terms were sown and transplanted manually on the first week of February at 40 cm inter raw spacings.

3.6 Treatments and Experimental Design
The experiments were arranged in a split –plot design with two factors; these were chemical fertilizers and compost levels with three replications. The main plots were assigned to chemical fertilizers as (urea and triple superphosphate) applied at sowing of cucumber and transplanting of tomatoes with two levels as follows:
0N0P: No chemical fertilizers
2N1P: (20g N +10g P₂O₅)/m².

The sub plots were assigned to the compost levels added two weeks before sowing of cucumber and transplanting of tomatoes as follows:
0C: No compost
1C: 2.5 Kg compost/m²

The control treatment (0N/0P/0C) received no chemical fertilizers and no compost.
All treatments received Calcium and Boronas foliar fertilizers (CALBORO2) at concentrations of 8% Ca and 2% B.
3.7 Nutrient analyses of the plant tissues

Leaves and fruits of cucumber and tomato were dried in air-forced oven (70 °C for 48 hours) ground, sieved and analyzed for N, P, and K content.

3.7.1 N content of plant tissues

Nitrogen content was determined using kjeldahl method according to Ryan et al. (2001).

3.7.2 P content of plant tissues

Leaves and fruits ashes were extracted by hydrochloric acid to determined Phosphorus content by using spectrophotometer (Ryan et al., 2001).

3.7.3 K content of plant tissues

Potassium content was determined by extracting the dry ashes by hydrochloric acid using flame photometer (Ryan et al., 2001).

3.8 Growth and yield parameters of tomato and cucumber

3.8.1 Plant height (cm)

An average height of random samples of three plants in each plot was taken every two weeks. The height was measured from the surface of the ground to the tip of the plant using a measuring tape.

3.8.2 Number of leaves per plant

The same samples used to determine the average plant height were also used to determine the number of leaves per plant by counting.

3.8.3 Number of fruits per plant

The count of fruits from three plants was made at random for each plot when maturity starts, and this activity continued till the end of the growing season.
3.8.4 Fruits yield (kg/m²)

The cucumber fruit picking was done at 2 – 3 days interval for two months and every 4 - 5 days interval for the last month, while for tomato fruit the picking was done every 2 - 3 days for two months. The total fruit yield (kg/m²) for each plot was taken for each of the two tested crops.

3.9 Statistical analysis

Statistical analysis of all measured and derived parameters was done by the standard analysis of variance (ANOVA) using M-stat computer package. Means between treatments were performed by the least significant difference (LSD) test for comparison.
CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Some physical and chemical properties of the studied soil

Data in table 4.1 show some physical and chemical properties of the soil of the experimental site. As seen the soil is silt loam with silt content > 70% and clay content about 25%, the air dry bulk density and soil porosity is about 1.67 and 37% respectively. The soil is neutral to slightly alkaline, non-calcareous, non – saline non - sodic. The organic carbon and total nitrogen content were low and hence the C/N ratio is low, while the available phosphorus is moderate (more than 10mg kg\(^{-1}\)). The results obtained indicated that, the riverine silt loam soil which classified as "Typicustifluvents is suitable for growth of tomato and cucumber under greenhouse conditions.

4.2 Nutrient content

4.2.1 Nitrogen content (mg plant\(^{-1}\)) of tomato leaves and fruits

Data for nitrogen content (mg plant\(^{-1}\)) of tomatoes leaves was shown in figure (4.1). The analysis of variance indicated that there was no significant difference in N content between treatments means, the data also showed that, the nitrogen content had highest value (87 mg plant\(^{-1}\)) in treatments receiving mineral fertilizer combined with compost followed by that of the treatment receiving mineral fertilizer alone. However, the data of nitrogen content due to application of compost alone was lower compared to that of the control treatment.

Figure (4.2) showed that, significant increase in nitrogen content (mg plant\(^{-1}\)) of fruits of tomato due to application of compost alone or combined with mineral fertilizer over the other treatments, without significant difference between their treatments means. These findings of nitrogen content in tomato leaves and fruits may be explained by the slow release of nutrients by compost and mobility of nitrogen in plants. These results are in line with those of Abdul \textit{et al.} (2013) and Laxminarayanan (2004) who reported high N uptake with combined application of organic and inorganic fertilizers.
### Table 4.1 Soil analysis of the studied soil

#### A. Chemical properties:

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH paste</th>
<th>EC (dSm(^{-1}))</th>
<th>CaCO(_3)</th>
<th>TN</th>
<th>O.C</th>
<th>C: N</th>
<th>Na(^+)</th>
<th>Ca(^{2+})</th>
<th>Mg(^+)</th>
<th>Cl(^-)</th>
<th>HCO(_3)^-</th>
<th>EXch Na(^+)</th>
<th>Exch K(^+)</th>
<th>CEC</th>
<th>SAR</th>
<th>ESP</th>
<th>Av. P mg kg(^{-1}) soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>7.6</td>
<td>0.5</td>
<td>3.8</td>
<td>0.043</td>
<td>0.088</td>
<td>2</td>
<td>3.0</td>
<td>1.5</td>
<td>.5</td>
<td>3.2</td>
<td>1.9</td>
<td>2.34</td>
<td>0.08</td>
<td>18</td>
<td>3</td>
<td>5</td>
<td>10.4</td>
</tr>
</tbody>
</table>

#### Physical properties:

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Mechanical analysis</th>
<th>Soil Moisture</th>
<th>Bulk Density</th>
<th>Porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CS</td>
<td>FS</td>
<td>Si</td>
<td>C</td>
</tr>
<tr>
<td>0-30</td>
<td>01</td>
<td>01</td>
<td>73</td>
<td>25</td>
</tr>
</tbody>
</table>
Fig. 4.1. Nitrogen content of tomato leaf

Fig. 4.2. Nitrogen content of tomato fruit
A similar trend in N content was noticed by Dikkova et al. (1981), Nandhakumar and Veeraragavathatham (2003). Sridharan et al. (2017) reported that, the uptake of nitrogen by the tomato plants showed a gradual increase with the progressive growth and development of the crop. Increase of nitrogen content in plant tissues in response to organic manure application is supported by many workers (Barker 1996; Karen et al., 1996; Fiona et al., 1998 and Kadir et al., 2000).

4.2.2 Phosphorus content (mg plant⁻¹) of tomato leaves and fruits

The results of phosphorus content were shown in figure (4.3) this result indicated that, application of compost, mineral fertilizer or their combinations significantly (P≤0.05) increased phosphorus content over that of the control. However, the treatment receiving compost alone significantly (P≤0.05) increased the phosphorus content in the leaf of tomato compared to those treatments receiving mineral fertilizer alone or combined with compost. The data in Figure (4.4) showed that, phosphorus content (mg plant⁻¹) of fruit of tomato significantly (P≤0.05) increased due to the application of organic, mineral fertilizer and their combinations compared to that of control treatment. P-content of treatments that received compost alone or compost combined with mineral fertilizer were significantly (P≤0.05) higher than that of treatment receiving mineral fertilizer alone. However the difference in P content between both treatments was insignificant. It is observed that the highest phosphorus content 66.7 mg/plant, was obtained by the fruits of tomato treated with compost coupled with mineral fertilizers. These results were in conformity with those of Islam and Munda (2012), Manoj et al. (2012) who reported that, the highest uptake of N, P and k with the application of N, P and K through inorganic fertilizers and organic fertilizer. Ghosh et al. (2014), Azam et al. (2013) supported the findings of Islam and Munda (2012), and those of Manoj et al. (2012) that the integration of organic fertilizers along with synthetic fertilizers results into highest P uptake by plants. Khan et al. (2017) reported that, the uptake of phosphorus by tomato plant was significantly increased by integrated use of compost and inorganic sources.
Fig. 4.3. Phosphorus content of tomato leaf

Fig. 4.4. Phosphorus content of tomato fruit
4.2.3 Potassium content (mg plant\textsuperscript{-1}) of tomato leaves and fruits

The content of K of leaves of tomato was shown in figure 4.5. The results showed that the K content of treatments that received compost alone or combined with mineral fertilizers were significantly (P≤0.05) higher than those treatment that received mineral fertilizer alone and that of the control treatment, without significant difference in K content between both treatments means. Application of compost alone gave highly significant increase (P≤0.05) in K content of leaves of tomato compared to results obtained by both application of mineral fertilizers and the control. Sreelatha et al. (2006) and Ghosh et al. (2014) reported that, combined use of organic and mineral fertilizers significantly increased the plant potassium uptake.

Figure 4.6 showed that, the maximum K content of 2.67 mg plant\textsuperscript{-1} of tomato fruits was recorded in treatment receiving compost alone. However, application of compost, mineral fertilizer and their combinations gave significant (P≤0.05) increased in K content of tomato fruit over that of the control. Also the results showed that, significant increase (P≤0.05) in K content of tomato fruits due to application of compost compare to those treatments that received mineral fertilizer alone or combined with compost; without significant difference in K content between both last treatments. The cause of more potassium uptake by tomato plants might be due to the effect of compost on solubilization of soil potassium. Sheoran et al. (2015) observed that, combined application of N based mineral fertilizers and vermin compost had significant increase of K uptake.
Fig. 4.5. Potassium content of tomato leaf

Fig. 4.6. Potassium content of tomato fruit
4.3 Effect of added compost and mineral fertilizers on growth and yield of tomato

4.3.1 Plant height (cm)

The analysis of variance (ANOVA) as shown in table (4.2) showed that, no significant differences in plant height was obtained at 15 and 30 days after transplanting (DAT) due to application of mineral fertilizers alone, compost alone or their combinations on tomato plant. However the least significant difference was obtained due to mineral fertilizer application over the other treatments followed by treatment received both mineral and compost application. Data obtained at 45DAT showed that, application of mineral fertilizers alone significantly (P ≤ 0.05) increased the plant height compared to that of the other treatments. The plant height at 55DAT was not significantly affected by application mineral fertilizers alone or compost alone or their combination, although the least significant difference was found associated with the application of the mineral fertilizer. These results were similar to those obtained by Noha et al. (2017) who found ,a dose of (26.7 g N+ 10.0 g P+ 53.3 g of K/m²)with (2 kg/m² of organic ) or without organic fertilizers gave the highest plant height.

4.3.2 Number of leaves per plant

Data in table (4.3) showed that, at 30 DAT there were no significant deference in the number of leaves per plant, between treatments means. The least significant difference increased in the number of leaves per plant was obtained due to application of mineral fertilizer alone or combined with compost. Similar to the results of the plant height obtained at 45 DAT applications of mineral fertilizers alone significantly (P ≤ 0.05) increased the number of leaves per plant compared to the other treatments. The data taken at55 DAT indicated that, there was no significant deference in the number of leaves per plant between treatments means. The highest number of leaves per plant was obtained due to application of mineral fertilizer alone or combined with compost. Least influenced of plant growth of tomato compatible with that of Fatimah et al. (2016) who reported that, compost mixed had the least influence in the growth stage of the studied tomato varieties.
### Table (4.2): Effect of compost and mineral fertilizers on plant height (cm)

**Treatment** | **Plant height (cm)** | **Means** | **Means** | **Means** | **Means** | **Means** | **Means** | **Means** | **Means**<br>**0 kg** | **2.5 kg**<br>**Com** | **Com** | **0 kg** | **2.5 kg**<br>**Com** | **Com** | **0 kg** | **2.5 kg**<br>**Com** | **Com**<br>**15 DAT** | **30 DAT**<br>**45 DAT**<br>**55 DAT**<br>**15 DAT** | **30 DAT** | **45 DAT**<br>**55 DAT**<br>**SE±(M)** | **SE±(C)**<br>**SE±(M*C)**<br>**LSD(M)**<br>**LSD(C)**<br>**LSD**<br>**C.V%**| **Means** | **Means** | **Means** | **Means**<br>**0 kg** | **2.5 kg**<br>**Com** | **Com** | **0 kg** | **2.5 kg**<br>**Com** | **Com** | **0 kg** | **2.5 kg**<br>**Com** | **Com**<br>**Means** | **Means** | **Means** | **Means**<br>**Means** | **Means** | **Means**<br>0N0P | 19.87 c | 19.0 c | 19.43 | 60.9 c | 62.0 c | 61.4 | 102.3 a | 103.3 a | 102.8 b | 169.3 b | 169.0 b | 169.2 | **2NIP** | 29.33 a | 23.77 b | 26.55 | 78.4 a | 76.7 b | 77.5 | 117 a | 110 a | 113.5 a | 194.3 a | 175.3 b | 184.8 | **Means** | 24.60 | 21.38 | 22.9 | 69.7 | 69.3 | 69.5 | 109.7 | 106.7 | 108.2 | 181.8 | 172.15 | 177 | **SE±(M)** | 2.235 | 3.64 | **.82** | 8.50 | 8.50 | **SE±(C)** | 1.043 | 1.59 | 3.25 | 3.34 | 3.34 | **SE±(M*C)** | 1.475 | 2.25 | 4.59 | 4.73 | 4.73 | **LSD(M)** | 13.597 | 22.18 | 5.02 | 51.73 | 51.73 | **LSD(C)** | 4.096 | 6.24 | 12.75 | 13.13 | 13.13 | **LSD** | 5.792 | 8.83 | 18.03 | 18.57 | 18.57 | **C.V%** | 11.1 | 5.6 | 7.4 | 4.6 | 4.6

**Note:**
- **DAT days after transplanting**
- *Means in same column followed by the same letter(s) are not significantly different according to least significant difference (LSD) Test P≤0.05.*
Table (4.3): Effect of application of compost on number of leaves per plant

<table>
<thead>
<tr>
<th></th>
<th>30 DAT</th>
<th></th>
<th>45 DAT</th>
<th></th>
<th>55 DAT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 kg</td>
<td>2.5 kg</td>
<td>Means</td>
<td>0 kg</td>
<td>2.5 kg</td>
<td>Means</td>
</tr>
<tr>
<td></td>
<td>Com</td>
<td>Com</td>
<td></td>
<td>Com</td>
<td>Com</td>
<td></td>
</tr>
<tr>
<td>0N0P</td>
<td>10 b</td>
<td>11.67 b</td>
<td>10.83 b</td>
<td>13.67 a</td>
<td>14.33 a</td>
<td>14 b</td>
</tr>
<tr>
<td>2NIP</td>
<td>12 a</td>
<td>12 a</td>
<td>12 a</td>
<td>15.33 a</td>
<td>14.33 a</td>
<td>14.83 a</td>
</tr>
<tr>
<td>SE±(M)</td>
<td>0.312</td>
<td></td>
<td>0.118*</td>
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<td></td>
<td>1.852</td>
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<tr>
<td>SE±(C)</td>
<td>0.236</td>
<td></td>
<td>0.471</td>
<td></td>
<td></td>
<td>0.486</td>
</tr>
<tr>
<td>SE±(M*C)</td>
<td>0.333</td>
<td></td>
<td>0.667</td>
<td></td>
<td></td>
<td>0.687</td>
</tr>
<tr>
<td>LSD(M)</td>
<td>1.897</td>
<td></td>
<td>0.717</td>
<td></td>
<td></td>
<td>11.270</td>
</tr>
<tr>
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<td>1.851</td>
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<td>1.908</td>
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<tr>
<td>LSD(M*C)</td>
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<td>1.830</td>
<td></td>
<td></td>
<td>10.385</td>
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<tr>
<td>C.V%</td>
<td>5.1</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

*DAT days after transplanting

*Means in same column followed by the same letter(s) are not significantly different according to least significant difference (LSD) Test P≤0.05.
4.3.2 Effect of compost and minerals fertilizers on yield of tomato

Effect of application of mineral fertilizers and compost on the number of fruit and yield of tomato was shown in the Table 4.4. The data taken at the first harvest showed that, the treatments that received mineral fertilizer alone or combined with compost gave high significant increase ($P \leq 0.01$) of number of fruit pre plant over that of both the compost and the control treatments. The maximum number of fruits per plant (27) was found associated with the application of mineral fertilizer combined with the compost, although application of compost alone revealed significant increase ($P \leq 0.05$) in the number of fruits compared to the control treatment. Ogundare et al. (2015) and Noha et al. (2017) reported that, the number of fruits per plant was significantly increased by the combined use of organic and inorganic fertilizer.

The total yield of tomatoes (kg/m$^2$) of the 10 harvests was highly increased ($P \leq 0.01$) by application of compost combined with mineral fertilizer and that, the application of compost alone was significantly ($P \leq 0.05$) superior over the treatment that received the mineral fertilizer alone, which significantly ($P \leq 0.05$) increased tomato yield when compared to the control treatment. These findings were in agreement with that of Ogundare (2011) and Asadu and Unagwu, (2012) who reported that, the better performance of crop in terms of growth and yield was observed when organic manure was combined with NPK fertilizer. Also this better response to compost may be explained as mentioned by Martini et al.(2004), Adekiya and Agbede (2009), Parry et al .(2009) Ibrahim and Fadni (2013) who stated that, compost was probably contributed to a better and more balanced nutrient supply, matching well the nutrient requirements of tomatoes because it mineral release from compost increased with time. Thayamini (2016) reported that Organic manure contains high amount of organic matter which improves the water holding capacity and soil microbial activity which may increase the fruit set and the subsequent fruit development. These results suggested that, application of compost combined with mineral fertilizers reduced the excessive use of mineral fertilizers for production of tomatoes under greenhouse conditions.
Table (4.4): Effect of compost and mineral fertilizers on yield of tomato

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield Parameter</th>
<th>Means</th>
<th>Means</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Fruit per plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 kg Com</td>
<td>2.5 kg Com</td>
<td></td>
<td>0 kg Com</td>
</tr>
<tr>
<td>0N0P</td>
<td>10.7 d</td>
<td>14.7 c</td>
<td>12.7</td>
<td>20.9 c</td>
</tr>
<tr>
<td>2NIP</td>
<td>26 b</td>
<td>27 a</td>
<td>26.15</td>
<td>23.8 c</td>
</tr>
<tr>
<td>Means</td>
<td>18</td>
<td>20.8</td>
<td>38.8</td>
<td>22.3 b</td>
</tr>
<tr>
<td>SE± (M)</td>
<td>0.35**</td>
<td></td>
<td></td>
<td>4.2*</td>
</tr>
<tr>
<td>SE± (C)</td>
<td>0.72*</td>
<td></td>
<td></td>
<td>1.2**</td>
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<td></td>
<td>1.7</td>
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<tr>
<td>LSD(M)</td>
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<td></td>
<td></td>
<td>2.9</td>
</tr>
<tr>
<td>LSD(M*C)</td>
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<td></td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td>LSD</td>
<td>3</td>
<td></td>
<td></td>
<td>7.6</td>
</tr>
<tr>
<td>C.V%</td>
<td>9.04</td>
<td></td>
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<td>10.3</td>
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</table>

*Means in same column followed by the same letter(s) are not significantly different according to least significant difference (LSD) Test P ≤ 0.05.
4.4 Nutrient contents of leaves and fruits

4.4.1 Nitrogen content (mg plant\(^{-1}\)) of cucumber leaves and fruits

Figure (4.7) showed that, nitrogen content (mg plant\(^{-1}\)) of leaves of cucumber significantly (P≤0.05) increased due to application of compost compared to that of the other treatments. Also results showed significant difference in N content between the combined compost with mineral treatment over that of treatment that received mineral fertilizer alone and the control, without significant difference in N content between both latter treatments.

The data of nitrogen content (mg plant\(^{-1}\)) of cucumber fruits was shown by Figure (4.8) that, revealed no significant difference in N content due to application of mineral fertilizer, compost or their combination, although the highest value (203 mg plant\(^{-1}\)) was found associated with the addition of mineral fertilizers compared to that of others treatment.

4.4.2 Phosphorus content (mg plant\(^{-1}\)) of cucumber leaves and fruits

Data in Figure (4.9) and Figure (4.10) showed that, the means of phosphorus contents (mg plant\(^{-1}\)) of leaves and fruits of cucumber there were not significantly different between the treatments. The highest value (43.8mg plant\(^{-1}\)) and (53.9 mg plant\(^{-1}\)) of leaves and fruits respectively were associated with the combined treatment of organic and chemical fertilizer, while the lowest values (19.3 mg plant\(^{-1}\)) of both leaves and fruits were with the control treatment. This result could be attributed to presumable better availability of nutrients when plants received combination of inorganic and organic fertilizers, similar results were also noticed by Anjanappa et al. (2012). Anjanappa et al. (2013) indicated that, the application of organic fertilizers enhanced the colonization of mycorrhiza which improves phosphorus supply and that the organic fertilizers released nutrients slowly and there by contribute to the residual pool of organic N and P in the soil.
Fig. 4.7. Nitrogen content of cucumber leaf

Fig. 4.8. Nitrogen content of cucumber fruit
Fig. 4.9. Phosphorus content of cucumber leaf

Fig. 4.10. Phosphorus content of cucumber fruit
4.4.3 Potassium content (mg plant$^{-1}$) of cucumber leaves and fruits

The content of K of leaves of cucumber was shown in Fig. 4.11. The data indicated that, there were no significant differences in K content between treatment means. The highest K content of leaves (5.4 mg plant$^{-1}$) was related to the treatment that received 2.5 kg compost/m$^2$, followed by that of treatment that received 20gN+10gP$_2$O$_5$ + 2.5 kg compost/m$^2$ (4.76 mg plant$^{-1}$). Similarly the contents of K of the fruits of cucumber indicated no significant differences in K contents between treatments. The highest K content of the fruits (8.68 mg plant$^{-1}$) was related to the treatment that received compost alone followed by the treatment that received mineral fertilizer alone (6.84 mg plant$^{-1}$). These findings are in conformity with those of Alifar et al. (2010) and Ahmad and Mahmoud, (2012) who argued that, organic and inorganic substrates had no significant difference on concentration of macro and micro elements in the leaf of cucumber.
Fig. 4.11. Potassium content of cucumber leaf

Fig. 4.12. Potassium content of cucumber fruit
4.5 Effect of compost and mineral fertilizers on growth and yield of cucumber

4.5.1 Plant height (cm)

Results obtained at 15, 30, 45 and 55 days after sowing (DAS) were shown in Table (4.4). The analysis of variance (ANOVA) indicated that, there was significant (P≤0.05) increase in plant height of cucumber due to application of compost alone, or compost combined with mineral fertilizer compare to that of the treatment that received mineral fertilizer alone and the control treatment; without significant difference in plant height between treatment means of both compost and the compost combined mineral fertilizer treatments for the data taken at 15 and 45 DAS. Whereas the data taken at 30 and 55 DAS showed significant difference in plant height between them. The tallest plants were related to the combined treatment and the shortest plants was found associated with the control treatment. The data indicated the positive effect of application of compost alone or combined with mineral fertilizers on plant height. Manal et al. (2017) found that, the addition of compost alone or in combination with urea nitrogen improved soil properties and hence growth and yield. Also similar results were obtained by Eifediyi and Remison (2010).
Table (4.5): Effect of compost and mineral fertilizers on plant height of cucumber

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>15 DAS</th>
<th>30 DAS</th>
<th>45 DAS</th>
<th>55 DAS</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 kg Com</td>
<td>2.5 kg Com</td>
<td>0 kg Com</td>
<td>2.5 kg Com</td>
<td>0 kg Com</td>
<td>2.5 kg Com</td>
</tr>
<tr>
<td>0N0P</td>
<td>4.59 a</td>
<td>6.15 a</td>
<td>5.37</td>
<td>10.70 c</td>
<td>31.90 b</td>
<td>21.30</td>
</tr>
<tr>
<td>2NIP</td>
<td>6.56 a</td>
<td>7.70 a</td>
<td>7.12</td>
<td>13.77 c</td>
<td>44.33 a</td>
<td>29.05</td>
</tr>
<tr>
<td>Means</td>
<td>5.56 b</td>
<td>6.92 a</td>
<td>6.24</td>
<td>12.23</td>
<td>38.12</td>
<td>25.18</td>
</tr>
<tr>
<td>SE±(M)</td>
<td>1.045</td>
<td>1.584</td>
<td>8.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE±(C)</td>
<td>.289*</td>
<td>1.043***</td>
<td>2.34***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE±(M*C)</td>
<td>1.084</td>
<td>1.476*</td>
<td>3.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>6.356</td>
<td>9.636</td>
<td>49.93</td>
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<td></td>
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<tr>
<td>LSD</td>
<td>1.135</td>
<td>4.097</td>
<td>9.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>5.813</td>
<td>7.639</td>
<td>45.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V%</td>
<td>11.3</td>
<td>10.2</td>
<td>3.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DAS days after sowing**

*Means in same column followed by the same letter(s) are not significantly different according to least significant difference (LSD) Test P≤.0.05.*
4.5.2 Number of leaves per plant

Data of number of leaves per plant were shown in Table (4.3). The data taken at 15 DAS showed there was no significant deference in number of leaves per plant between treatments means, while the data taken at 30 and 45 DAS indicated that, treatment that received compost alone or compost combined with mineral fertilizer gave high significant (P≤0.01) increase in number of leaves per plant compared to that of treatment that received mineral fertilizer alone and the control treatment. The addition of mineral fertilizer alone significantly (P ≤0.05) increased the number of leaves per plant over that of the control treatment at 45 DAS. Analysis of variance (ANOVA) of the data taken at 55 DAS showed that, there significant differences (P≤0.05) in number of leaves / plant were due to the addition of each of mineral fertilizer or compost compared to that of the control treatment. The combined application of organic and inorganic fertilizers did not give significant difference in number of leaves over their individual application. The highest number of leaves per plant was related to the combined treatment during the growth period. These results were in line with those of Eifediyi and Remison (2010).
Table (4.6): Effect application of compost and mineral fertilizers on number of leaves per plant

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of leaf per plant</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 DAS</td>
<td>30 DAS</td>
</tr>
<tr>
<td></td>
<td>0 kg Com</td>
<td>2.5 kg Com</td>
</tr>
<tr>
<td>0N0P</td>
<td>3.33 a</td>
<td>3.67 a</td>
</tr>
<tr>
<td>2NIP</td>
<td>3.67 a</td>
<td>4 a</td>
</tr>
<tr>
<td>Means</td>
<td>3.5</td>
<td>3.8</td>
</tr>
<tr>
<td>SE±(M)</td>
<td>0.236</td>
<td>0.1667*</td>
</tr>
<tr>
<td>SE±( C)</td>
<td>0.333</td>
<td>0.1667**</td>
</tr>
<tr>
<td>SE±(M*C)</td>
<td>0.408</td>
<td>0.2357</td>
</tr>
<tr>
<td>LSD</td>
<td>1.434</td>
<td>0.7171</td>
</tr>
<tr>
<td>LSD</td>
<td>1.309</td>
<td>0.4627</td>
</tr>
<tr>
<td>LSD</td>
<td>1.413</td>
<td>0.5947</td>
</tr>
<tr>
<td>C.V%</td>
<td>22.3</td>
<td>4.1</td>
</tr>
</tbody>
</table>

*Means in same column followed by the same letter(s) are not significantly different according to least significant difference (LSD) Test \( P \leq 0.05 \).
4.5.3 Effect of compost and mineral fertilizers on yield of cucumber kg/m²

The total yield of cucumber (kg/m²) of the 4 harvests was highly significantly increased (P≤0.01) due to application of compost alone or compost combined with mineral fertilizer over that of the mineral fertilizer and control treatment, without significant difference between the latter treatments. This result might be attributed to the fact that application of compost improved both physical and chemical properties of the soil which in turn positively affected plants growth. These findings were in agreement with those of Aly (2002) who studied the effect of applying organic and chemical fertilizers on cucumber yield and fruit characteristics and found that, organic fertilizer gave significantly greater early, exportable and total yield than inorganic fertilizers. Basel and Sami (2014) found that, application of compost improved the soil characteristics, increased production of cucumber and organic matter content of the soil. Eifediyi and Remison (2010) reported that, the combined application of organic and inorganic fertilizer significantly increased cucumber yields compared to that of the application of each one of them separately particularly at higher rates of application. The increase in yield of cucumber could be attributed to the fact that nutrients were more readily available when organic and inorganic fertilizers were combined in addition to improvement of soil physical characteristics.
Table (4.7): Effect of compost and mineral fertilizers on yield of cucumber

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield kg/m²</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 kg Com</td>
<td>2.5 kg Com</td>
</tr>
<tr>
<td>0N0P</td>
<td>10.53 c</td>
<td>20.67 b</td>
</tr>
<tr>
<td>2NIP</td>
<td>12.23 c</td>
<td>21.43 a</td>
</tr>
<tr>
<td>Means</td>
<td>11.4</td>
<td>21</td>
</tr>
</tbody>
</table>

SE± (M) 0.944
SE± (C) 0.825**
SE±( M*C) 1.254
LSD 5.746
LSD 3.239
LSD 4.612
C.V% 12.5

*Means in same column followed by the same letter(s) are not significantly different according to least significant difference (LSD) Test P≤0.05.*
CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- Application of compost at a rate of 2.5 kg/m$^2$ alone or combined with mineral fertilizer at a rate 20g N +10g P$_2$O$_5$ to riverine silt loam soil in cooled plastic house improved the content of N, P and K in cucumber and tomato.
- No significant differences in plant height and number of leaves of tomato were obtained at 15, 30 and 55 days after transplanting (DAT) due to application of both compost and mineral fertilizers or their combinations. However, the data obtained at 45 DAT showed that, application of mineral fertilizers alone significantly (P≤0.05) increased both of the growth parameters i.e. plant height and number of leaves of tomato.
- Mineral fertilizer alone or combined with compost revealed high significant increase (P≤0.01) on number of tomatoes fruit per plant over that of the compost and control treatments. The maximum number of fruits was associated with the application of mineral fertilizer combined with the compost. Also application of compost alone gave a significant increase (P≤0.05) of the number of fruit / plant compared to that of the control treatment.
- The yield of tomatoes (kg/ m$^2$) was highly increased (P≤0.01) by application of compost combined with mineral fertilizer and that the application of compost alone was significantly (P≤0.05) superior over that of the treatment received the mineral fertilizer alone, which was significantly (P≤0.05) increased tomato yield when compared to the control treatment.
- Application of compost alone or combined with mineral fertilizer significantly (P≤0.01) the improved growth parameters (plant height and number of leaves) and yield of cucumber compare to that of the treatment that received mineral fertilizer alone and the control treatment.
5.2 Recommendations

Based on the above mentioned conclusions:

- Application of compost as organic fertilizer can reduce and compensate the excessive applications of chemical fertilizers usually added by farmers for tomato and cucumber production under greenhouses conditions.

- Further researches are needed to test the amount of added NPK inorganic fertilizers doses as drip fertigation in addition to the basal application of compost and N and P mineral fertilizers on growth and yield of tomato and cucumber under greenhouse condition.
REFERENCES


Andersen, P.C., Rhoads, F.M., Olson, S.M. and Brodbeck, B.V. (1999a). Relationships of nitrogenous compounds in petiole sap of tomato to nitrogen fertilization and the value of these compounds as a predictor of yield. HortScience 34: 254–258


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APPENDICES

Appendix (1): Harvest of tomato

![Diagram showing harvest kg/M² over number of harvests for different categories: ONOPOC, ONOP1C, 2N1POC, and 2N1P1C.]
Appendix (2): Harvest of cucumber